CLAIMS

What is claimed is:

1. A radiation patternable functional material, comprising:
   a) nanoparticles of an electronically functional substance; and
   b) a plurality of ligands bound to each of said nanoparticles, said ligands containing a photoreactive group or a group that is reactive with a photochemically generated species and that, after first-order photoreaction or reacting with said photochemically generated species, materially changes the solubility characteristics of said material in a developer.

2. The material of Claim 1, wherein said electronically functional substance comprises a member of the group consisting of semiconductors, metals, dielectrics and phosphors.

3. The material of Claim 2, wherein said electronically functional substance comprises a member of the group consisting of semiconductors and metals.

4. The material of Claim 3, wherein said electronically functional substance comprises one or more members of the group consisting of silicon, germanium, CdS, CdSe, InP, InAs and GaAs.

5. The material of Claim 4, wherein said electronically functional substance comprises silicon.

6. The material of Claim 3, wherein said electronically functional substance comprises one or more members of the group consisting of transition metals, noble metals, aluminum, indium, tin, lead, and alloys thereof.

7. The material of Claim 6, wherein said electronically functional substance comprises one or more members of the group consisting of Cr, Mo, W, Fe, Ru, Ni, Pd, Pt, copper, silver, gold, and aluminum.

8. The material of Claim 7, wherein said electronically functional substance comprises nickel, copper, silver or gold.

9. The material of Claim 2, wherein said electronically functional substance comprises an oxide, nitride, oxynitride, carbide or sulfide of a metal or metalloid.

10. The material of Claim 1, wherein said ligands contain a group that is reactive with said photochemically generated species and that, after reacting with said photochemically generated species, materially changes the solubility characteristics of said material in said developer.

11. The material of Claim 10, wherein said photoreactive group comprises a quinone, and said ligand comprises a phenol.

12. The material of Claim 1, wherein said ligands are bound to said nanoparticles by covalent, coordination and/or ionic bonds.

13. The material of Claim 12, wherein said ligands are bound to said nanoparticles through at least one nanoparticle-binding member selected from the group consisting of an alcoholate, a thiolate, a disulfide, a carboxylate, a carboxylic acid, an amine, a phosphine, a phosphine oxide and an alkyl group.

14. The material of Claim 1, wherein said group that is reactive with said photochemically generated species is selected from the group consisting of a carbon-carbon double bond, an epoxide, an oxirane, an aziridine, a phenol, a carbonate and a carbamate.

15. The material of Claim 14, wherein said group that is reactive with said photochemically generated species comprises said carbon-carbon double bond, and said carbon-carbon double bond is selected from the group consisting of a vinyl group, an activated carbon-carbon double bond, an acrylate, and a vinyl ketone.

16. The material of Claim 1, wherein said nanoparticles have an average diameter of less than 100 nm.

17. The material of Claim 1, wherein said nanoparticles have an average diameter of less than 10 nm.

18. The material of Claim 1, wherein said nanoparticles have an average diameter of less than 5 nm.

19. The material of Claim 1, wherein said photochemically generated species has an ultraviolet absorption maximum at a first wavelength and said nanoparticles have an ultraviolet absorption maximum at a second wavelength, said second wavelength significantly differing from said first wavelength.

20. The material of Claim 19, wherein said photoreactive group comprises an azide, said first wavelength is one at which a mercury arc lamp has a relatively strong irradiance, and said nanoparticles comprise a metal having a relatively poor absorbance at said first wavelength.

21. A compound of the formula (1):

$$(R^1\text{-}X^1)_mNP(X^2\text{-}R^2\text{-}Y)_n, \quad (1)$$

where NP comprises a nanoparticle of an electronically functional substance; Y is a group that is photoreactive or that is reactive with a photochemically generated species and which, after first-order photoreaction or reacting with said photochemically generated species, materially changes the solubility characteristics of said compound in a developer; X^1 and X^2 are independently a nanoparticle-binding group; R^1 is a monovalent group that is not reactive with said photochemically generated species; R^2 is a divalent bridging group; m is at least 0, and the m instances of $R^1\text{-}X^1$ may be the same or different; and n is at least 1, and the n instances of $X^2\text{-}R^2\text{-}Y$ may be the same or different.

22. The compound of Claim 21, wherein said electronically functional substance comprises a member of the group consisting of semiconductors and metals.

23. The compound of Claim 22, wherein said electronically functional substance consists essentially of silicon and/or germanium.

24. The compound of Claim 22, wherein said electronically functional substance comprises one or more members of the group consisting of transition metals, noble metals, aluminum, indium, tin, lead, and alloys thereof.

25. The compound of Claim 24, wherein said electronically functional substance consists essentially of nickel, copper, silver or gold.

26. The compound of Claim 22, wherein said electronically functional substance comprises an oxide, nitride, oxynitride, carbide or sulfide of a metal or metalloid.

27. The compound of Claim 21, wherein R^1 is alkyl, cycloalkyl, aryl or aralkyl, any one of which may be substituted one or more times with a halogen or with a substituent selected from the group consisting of alkyl (except where R^1 = alkyl), cycloalkyl, aryl, aralkyl (except where R^1 = alkyl), alkoxy, alkylthio, alkylcarbonyl, alkoxycarbonyl, alkylcarboxy, alkylamino, dialkylamino, alkylamido, dialkylamido, cycloalkoxy, cycloalkylthio, cycloalkylcarbonyl, cycloalkoxycarbonyl, cycloalkylcarboxy, cycloalkylamino, di(cycloalkyl)amino, (cycloalkyl)(alkyl)amino, cycloalkylamido, di(cycloalkyl)amido, (cycloalkyl)(alkyl)amido, aryloxy, arylthio, arylcarbonyl, aryloxycarbonyl, arylcarboxy, arylamino, diarylamino, (aryl)(alkyl)amino, arylamido, aralkoxy, aralkylthio, aralkylcarbonyl, aralkoxycarbonyl, aralkylcarboxy, aralkylamino, diaralkylamino, (aralkyl)(alkyl)amino, heterocyclyl, trialkylsilyl, and trialkylsilyloxy, each of which may be further substituted with one or more halogens, alkyl groups (except for alkyl substituents on R^1) and/or alkoxy groups.

28. The compound of Claim 27, wherein R^1 is C_4-C_{20} alkyl which may be substituted one or more times with a halogen, a C_1-C_6 alkoxy, C_3-C_8 cycloalkyl, phenyl and/or C_7-C_{20} aralkyl, each of which (except for halogen) may be further substituted with one or more halogens, C_1-C_6 alkyl groups and/or C_1-C_6 alkoxy groups.

29. The compound of Claim 21, wherein R^2 is selected from the group consisting of alkylene, alkyleneoxy, alkyleneoxyalkylene, alkyleneoxyalkyleneoxy, alkylenethio, alkylenethioalkylene, alkylenecarbonyl, alkyleneoxycarbonyl, alkylenecarboxy, alkyleneamino, alkylene(alkyl)amino, alkylene(alkyl)aminoalkylene, alkyleneamido, alkylene(alkyl)amido, cycloalkylene, cycloalkyleneoxy, cycloalkylenethio, cycloalkylenecarbonyl, cycloalkyleneoxycarbonyl, cycloalkylenecarboxy, cycloalkylene-amino, (cycloalkylene)(alkyl)amino, cycloalkyleneamido, (cycloalkylene)(alkyl)amido, arylene, alkylene-arylene, alkylene-arylene-alkylene, aryleneoxy, alkyleneoxyarylene, alkylene-aryleneoxy, aryleneoxyalkylene, arylenethio, alkylene-arylenethio,

arylenethioalkylene, arylenecarbonyl, alkylene-arylenecarbonyl, aryleneoxycarbonyl, alkylene-aryleneoxycarbonyl, arylenecarboxy, alkylene-arylenecarboxy, aryleneamino, alkylene-aryleneamino, arylene(aryl)-amino, alkylene-arylene(aryl)amino, arylene(alkyl)amino, alkylene-arylene(alkyl)amino, alkylene(aryl)amino, aryleneamido, aralkylene, aralkyleneoxy, (alkylene)aralkyleneoxy, aralkylenethio, aralkylenecarbonyl, aralkyleneoxycarbonyl, aralkylenecarboxy, aralkyleneamino, aralkylene(aryl)amino, (aralkylene)(alkyl)amino, (alkylene)(aralkyl)amino, heterocyclylene, alkylene-heterocyclylene, and alkylene-heterocyclylene-alkylene, each of which may be further substituted with one or more halogens, alkyl groups (except where R^2 = alkylene), alkoxy groups, trialkylsilyl, and/or trialkylsilyloxy groups.

30. The compound of Claim 29, wherein R^2 is selected from the group consisting of alkylene, alkylene substituted with one or more halogens and/or alkoxy groups, alkyleneoxy, alkyleneoxyalkylene, alkyleneoxyalkyleneoxy, alkylene(alkyl)amino, cycloalkylene, arylene, arylene substituted with one or more halogens, alkyl groups and/or alkoxy groups, aryleneoxy, arylenethio, arylene(alkyl)amino, aralkylene, (alkylene)aralkylene, and aralkylene(alkyl)amino.

31. The compound of Claim 30, wherein R^2 is selected from the group consisting of C_4-C_{20}, branched or unbranched, saturated or unsaturated alkylene groups; C_7-C_{17}, branched or unbranched, substituted or unsubstituted aralkylene groups; C_4-C_{20}, branched or unbranched, saturated or unsaturated alkyleneoxy groups; and C_4-C_{20}, branched or unbranched, saturated or unsaturated alkylene thio groups.

32. The compound of Claim 21, wherein Y is reactive with a photochemically generated species and which, after reacting with said photochemically generated species, materially changes the solubility characteristics of said material in said developer.

33. The compound of Claim 32, wherein Y is selected from the group consisting of a carbon-carbon double bond, an epoxide, an oxirane, an aziridine, and a phenol.

34. The compound of Claim 32, wherein Y is selected from the group consisting of a vinyl group, a vinylidene group, an epoxide, a carbonate, a carbamate and a phenol.

35. The compound of Claim 34, wherein Y comprises a vinyl group or a vinylidene group substituted with a halogen, a C_1-C_6 alkyl group, a C_1-C_6 alkoxy group, a phenyl group, a phenyl group substituted with one or more halogens, C_1-C_6 alkyl groups, C_1-C_6 alkoxy groups and/or di-(C_1-C_6 alkyl)amino groups, a -C(=O)-C_1-C_6 alkyl group, a -C(=O)-C_1-C_6 alkoxy group, or a cyano group.

36. The compound of Claim 21, wherein X^1 and X^2 are independently a chalcogen, a carboxylate group, a carboxylic acid group, a thiocarboxylate group, a thiocarboxylic acid group, an alkylene group, NR^5_u (where u is from 0 to 2 and each R^5 is independently H or a C_1-C_6 alkyl group), $S(O)_x$ (where x is from 1 to 3), PR^7_v (where v is from 0 to 3 and each R^7 is independently H, a C_1-C_6 alkyl group or a C_6-C_{10} aryl group which may be substituted with one or more halogen, C_1-C_4 alkyl, C_1-C_4 alkoxy, or di-C_1-C_4 alkylamino groups) or $P(O)_y(R^6)_z$ (where y is from 1 to 3, z is 1 or 2, and each R^6 is independently H, phenyl or a C_1-C_6 alkyl group).

37. The compound of Claim 36, wherein X^1 and X^2 are independently at least one nanoparticle-binding member is selected from the group consisting of O, S, a carboxylate, a carboxylic acid group, and a $-CH_2CH_2-$ group.

38. A radiation definable ink, comprising:

a) the material of Claim 1; and

b) a solvent in which said material is soluble.

39. The ink of Claim 38, further comprising a source of said photochemically generated species.

40. The ink of Claim 39, wherein said source of said photochemically generated species is selected from the group consisting of azides, photogenerated acid sources, photogenerated radical sources, carbonates, carbamates, and quinones.

41. The ink of Claim 39, wherein said source of said photochemically generated species is an azide, and said group that is reactive with said photochemically generated species comprises said carbon-carbon double bond.

42. The ink of Claim 39, wherein said source of said photochemically generated species is a photogenerated acid source, and said group that is reactive with said photochemically generated species is selected from the group consisting of an epoxide, an oxirane, an aziridine, and an activated carbon-carbon double bond.

43. The ink of Claim 39, wherein said source of said photochemically generated species is a photogenerated radical source, and said group that is reactive with said photochemically generated species comprises an acrylate.

44. The ink of Claim 38, wherein said ligands contain said photochemically reactive group, and said photochemically reactive group comprises a carbonate and/or a carbamate.

45. The ink of Claim 38, wherein said photoreactive group comprises a quinone, and said ligand comprises a phenol.

46. The ink of Claim 38, wherein said material is present in said ink in a percentage by weight of from 0.1% to 50%.

47. The ink of Claim 38, wherein said solvent is selected from the group consisting of alkanes, alkenes, halogenated alkanes, halogenated alkenes, arenes, substituted arenes, alcohols, ethers, cyclic ethers, aliphatic ketones, aliphatic esters, aliphatic amides and aliphatic sulfoxides.

48. The ink of Claim 47, wherein said solvent is selected from the group consisting of C_6-C_{20} alkanes, C_6-C_{20} alkenes, benzene which may be substituted with from 1 to 3 C_1-C_4 alkyl groups, C_1-C_6 aliphatic alcohols, C_4-C_{20} ethers, C_4-C_{20} polyethers, C_4-C_{10} aliphatic ketones, and C_1-C_6 aliphatic esters of C_2-C_{12} aliphatic carboxylic acids that may be substituted with from 1 to 3 halogen atoms or a C_1-C_4 alkoxy group.

49. The ink of Claim 48, wherein said solvent comprises propylene glycol methyl ether acetate or ethyl ethoxypropionate.

50. The ink of Claim 47, further comprising one or more additives selected from the group consisting of a tension reducing agent, a surfactant, a thickening agent, and an adhesion promoter.

51. The ink of Claim 50, further comprising said adhesion promoter.

52. The ink of Claim 51, wherein said adhesion promoter comprises a C_6-C_{20}, branched or unbranched, mono- or polyunsaturated alkene; a C_8-C_{18}, branched or unbranched, substituted or unsubstituted mono- or polyunsaturated aralkene; a C_4-C_{20}, branched or unbranched, mono- or polyunsaturated alkenoic acid; a C_1-C_{20} branched or unbranched aliphatic alcohol ester of a C_2-C_{20}, branched or unbranched aliphatic acid, wherein at least

one of said aliphatic alcohol and said aliphatic acid contains at least 3 carbon atoms and at least one site of unsaturation; and/or a C_4-C_{20}, branched or unbranched, mono- or polyunsaturated aliphatic alcohol or aliphatic mercaptan.

53. A radiation definable ink, comprising:
    a) the compound of Claim 21; and
    b) a solvent in which said compound is soluble.

54. The ink of Claim 53, further comprising a source of said photochemically generated species.

55. The ink of Claim 54, wherein said source of said photochemically generated species is selected from the group consisting of azides, photogenerated acid sources, photogenerated radical sources and quinones.

56. The ink of Claim 54, wherein said source of said photochemically generated species is an azide, and said group that is reactive with said photochemically generated species comprises said carbon-carbon double bond.

57. The ink of Claim 54, wherein said source of said photochemically generated species is a photogenerated acid source, and said group that is reactive with said photochemically generated species is selected from the group consisting of an epoxide, an oxirane, an aziridine, and an activated carbon-carbon double bond.

58. The ink of Claim 54, wherein said source of said photochemically generated species is a photogenerated radical source, and said group that is reactive with said photochemically generated species comprises an acrylate.

59. The ink of Claim 53, wherein said ligands contain said photochemically reactive group, and said photochemically reactive group comprises a carbonate and/or a carbamate.

60. The ink of Claim 53, wherein said compound is present in said composition in a percentage by weight of from 0.1% to 50%.

61. The ink of Claim 53, further comprising one or more additives selected from the group consisting of a tension reducing agent, a surfactant, a thickening agent, and an adhesion promoter.

62. The ink of Claim 61, further comprising said adhesion promoter.

63. The ink of Claim 62, wherein said binder comprises a C_6-C_{20}, branched or unbranched, mono- or polyunsaturated alkene; a C_8-C_{18}, branched or unbranched, substituted or unsubstituted mono- or polyunsaturated aralkene; a C_4-C_{20}, branched or unbranched, mono- or polyunsaturated alkenoic acid; a C_1-C_{20} branched or unbranched aliphatic alcohol ester of a C_2-C_{20}, branched or unbranched aliphatic acid, wherein at least one of said aliphatic alcohol and said aliphatic acid contains at least 3 carbon atoms and at least one site of unsaturation; and/or a C_4-C_{20}, branched or unbranched, mono- or polyunsaturated aliphatic alcohol or aliphatic mercaptan.

64. A method of making the material of Claim 1, comprising the steps of:

a) reacting said nanoparticles of an electronically functional substance with one or more non-ligated compounds corresponding to said ligands having said photoreactive group or said group that is reactive with said photochemically generated species; and

b) isolating and/or purifying said material.

65. The method of Claim 64, wherein said nanoparticles of an electronically functional substance contain ligands not having said photoreactive group or said group that is reactive with said photochemically generated species.

66. The method of Claim 65, wherein said reacting comprises exchanging said non-ligated compounds for said ligands not having said photoreactive group or said group that is reactive with said photochemically generated species on said nanoparticles.

67. The method of Claim 65, wherein said reacting comprises mixing (1) nanoparticles of an electronically functional substance containing said ligands not having said photoreactive group or said group that is reactive with said photochemically generated species bound thereto and (2) said non-ligated compounds in a solvent for a length of time sufficient to exchange at least a portion of the non-ligated compounds for said ligands not having said photoreactive group or said group that is reactive with said photochemically generated species bound thereto.

68. The method of Claim 67, wherein said ligands not having said photoreactive group or said group that is reactive with said photochemically generated species bound thereto are present in an excess molar amount with respect to said nanoparticles.

69. The method of Claim 65, further comprising mixing a Lewis base with said nanoparticles having bound thereto ligands not containing said group that is reactive with said photochemically generated species and said non-ligated compounds to promote a ligand exchange.

70. A method of making the material of Claim 1,

a) mixing (i) said nanoparticles having bound thereto ligands not containing a group that is reactive with said photochemically generated species with (ii) one or more

non-ligated compounds corresponding to said ligands containing a group that is reactive with said photochemically generated species, said non-ligated compounds forming a van der Waals complex or micelle with said ligands bound to said nanoparticles and not containing a group that is reactive with said photochemically generated species; and

b) isolating and/or purifying said material.

71. The method of Claim 70, wherein said nanoparticles having bound thereto ligands not containing said group that is reactive with said photochemically generated species comprises (i) a nanoparticle core of said electronically functional substance, and (ii) long-chain alkyl groups covalently bound thereto.

72. The method of Claim 70, wherein said non-ligated compounds comprise a long-chain alkyl group covalently bound to said group that is reactive with said photochemically generated species.

73. The method of Claim 70, wherein said mixing step is conducted in a polar solvent.

74. A method of making the compound of Claim 21, comprising the steps of

a) mixing nanoparticles of the formula $NP(X^1\text{-}R^1)_k$, where k is an integer greater than 1 and where NP, X^1 and R^1 are as defined in Claim 21, with a molar excess of a compound of the formula $HX^2\text{-}R^2\text{-}Y$ or a salt thereof, where X^2, R^2 and Y are as defined in Claim 21, in a reaction mixture; and

b) isolating and/or purifying said compound of the formula (1) from said reaction mixture.

75. The method of Claim 74, further comprising mixing a Lewis base with said nanoparticles of the formula $NP(X^1\text{-}R^1)_k$ and said compound of the formula $HX^2\text{-}R^2\text{-}Y$ to promote a ligand exchange.

76. The method of Claim 74, wherein said compound of the formula $H\text{-}X^2\text{-}R^2\text{-}Y$ or a salt thereof is present in at least 4 times the molar amount of said nanoparticles.

77. The method of Claim 74, wherein $R^1\text{-}X^1$ is $R^1\text{-}C(=O)\text{-}O\text{-}$, and $H\text{-}X^2\text{-}R^2\text{-}Y$ is $H\text{-}S\text{-}R^2\text{-}Y$.

78. A method of making the compound of Claim 21,

a) either:

i) mixing nanoparticles of the formula $(R^1\text{-}X^1)_mNP(X^2\text{-}R^3\text{-}Z)_n$, where R^3 is any R^2 group, Z is a leaving group or electrophile, and NP, m, n, X^1, X^2, R^1 and R^2 are as defined in Claim 21, with a compound of the formula H-Y, H-Nu-Y, H-Nu-R^4-Y or a salt of such compounds, where Nu is a conventional nucleophile and R^4 is R^2 minus R^3, and Y is as defined in Claim 21, in a reaction mixture, or

ii) mixing nanoparticles of the formula $(R^1\text{-}X^1)_mNP(X^2\text{-}R^3\text{-}Nu\text{-}H)_n$ or a salt thereof with a compound of the formula Z-Y or Z-R^4-Y in a reaction mixture, where R^1, R^3, R^4, NP, m, n, X^1, X^2, Nu, Y and Z are as defined above; and

b) isolating and/or purifying said compound of the formula (1) from said reaction mixture.

79. The method of Claim 78, wherein said nanoparticles have the formula $(R^1\text{-}X^1)_mNP(X^2\text{-}R^3\text{-}OH)_n$, $(R^1\text{-}X^1)_mNP(X^2\text{-}R^3\text{-}COOR^5)_n$, $(R^1\text{-}X^1)_mNP(X^2\text{-}R^3\text{-}NZ_2)_n$, or $(R^1\text{-}X^1)_mNP(X^2\text{-}R^3\text{-}SH)_n$, X^2 is independently a carboxylate, a carboxylic acid, $-NR^8_2$, $-N^+R^8_3$, an oxygen atom or sulfur atom, R^8 is H or alkyl, and R^5 is H or an ester protecting group.

80. The method of Claim 78, wherein said mixing comprising mixing nanoparticles of the formula $(R^1\text{-}X^1)_mNP(X^2\text{-}R^3\text{-}Z)_n$, where NP consists essentially of a metal and X^2 is a carboxylate, a carboxylic acid or S, with said compound of the formula H-Nu-Y, H-Nu-R^4-Y or a salt thereof, where NuH is -NHR^8, OH or SH (except that NuH is OH when X^2 is said carboxylate or carboxylic acid) and R^8 is H or alkyl.

81. The method of Claim 78, wherein NP consists essentially of silicon or a silicon-germanium mixture, X^2 is alkylene or O, and said compound of the formula H-Y, H-Nu-Y, or H-Nu-R^4-Y is either H-Nu-Y or H-Nu-R^4-Y, where H-Nu is COOH, NHR^8 or SH, and R^8 is H or alkyl.

82. The method of Claim 78, comprising mixing nanoparticles of the formula $(R^1\text{-}X^1)_mNP(X^2\text{-}R^3\text{-}Z)_n$ with a compound of the formula H-Y or a salt thereof.

83. The method of Claim 78, wherein Y is a cyanide, azide, hydroxide or sulfide anion.

84. The method of Claim 78, comprising mixing nanoparticles of the formula $(R^1\text{-}X^1)_mNP(X^2\text{-}R^3\text{-}Nu\text{-}H)_n$ or a salt thereof with a compound of the formula Z-Y or Z-R^4-Y.

85. The method of Claim 84, wherein Nu comprises a chalcogenide atom, a phenolate anion, an amine, a carboxylate or an aryl group, and said compound of the formula Z-Y or Z-R^4-Y comprises an aliphatic carboxylic acid anhydride, an allyl halide, or an aliphatic acyl chloride.

86. A method of making the compound of Claim 21, comprising the steps of

a) reacting nanoparticles of the formula $(R^1\text{-}X^1)_mNP(X^1\text{-}R^3\text{-}(CR{=}CR'R''))_k$, where k is an integer greater than 1, NP, R^1 and X^1 are as defined in Claim 21, R^3 is R^2 or a

precursor thereof, and R, R′ and R″ are independently H, C_1-C_6 alkyl, C_2-C_6 alkenyl, C_1-C_6 alkoxy, mono- or di-C_1-C_6 alkyl amino, a cyclic amino group, C_6-C_{10} aryl (which may be substituted one or more times with C_1-C_6 alkyl, C_2-C_6 alkenyl, C_1-C_6 alkoxy, mono- or di-C_1-C_6 amino or halogen); –C(=O)O-C_1-C_6 alkyl or –C(=O)C_1-C_6 alkyl, with an epoxidizing agent or source of Y^+, Y^- or $Y\cdot$; and

b) isolating and/or purifying said compound of the formula (1) from said reaction mixture.

87. The method of Claim 86, wherein R, R′ and R″ are independently H or C_1-C_6 alkyl.

88. The method of Claim 86, wherein said reacting is with said epoxidizing agent.

89. The method of Claim 86, wherein said reacting is with said Y^+ source and comprises electrophilically adding Y from Z-Y to the CR=CR′R″ group.

90. The method of Claim 86, wherein said reacting is with said Y^- source and comprises electrophilically adding HY to the CR=CR′R″ group.

91. The method of Claim 86, wherein said reacting is with said $Y\cdot$ source and comprises radical addition of Y from HY or Y_2 to the CR=CR′R″ group.

92. A method of making an electronically functional thin film, comprising the steps of:

a) irradiating the ink of Claim 38 to form an irradiated composition; and

b) curing said irradiated composition to form said electronically functional thin film.

93. The method of Claim 92, further comprising, after said irradiating step and before said curing step, the step of developing said irradiated composition to form a patterned thin film.

94. The method of Claim 93, wherein said irradiating step comprises selectively irradiating portions of said composition, and said developing step comprises removing either irradiated or non-irradiated portions of said layer to form said patterned thin film.

95. The method of Claim 94, wherein said selectively irradiating substep comprises (i) positioning at least one of said substrate and a mask such that said portions can be selectively irradiated and said non-irradiated portions cannot be irradiated, and (ii) irradiating said layer with ultraviolet light through said mask.

96. The method of Claim 92, wherein said composition comprises metal, dielectric, phosphor and/or semiconductor nanoparticles.

97. The method of Claim 96, wherein said nanoparticles comprise metal nanoparticles.

98. The method of Claim 93, wherein said curing step comprises sintering said developed film to form a patterned electronically functional thin film.

99. The method of Claim 98, wherein said curing step comprises heating said composition to a temperature of at least about 100 °C for a period of time sufficient to remove substantially all of said ligand(s).

100. The method of Claim 99, wherein said curing temperature is at least about 200 °C.

101. The method of Claim 100, wherein said curing temperature is at least about 300 °C.

102. The method of Claim 101, wherein said curing temperature is at least about 400 °C.

103. The method of Claim 99, further comprising heating said electronically functional thin film to a temperature of at least about 200 °C in the presence of a reducing atmosphere to passivate said electronically functional thin film.

104. The method of Claim 103, wherein said heating temperature is at least about 300 °C.

105. The method of Claim 92, further comprising depositing said composition on a substrate.

106. The method of Claim 105, wherein said depositing comprises inkjetting, spin coating, dip coating, meniscus, extrusion or spray coating a solution, emulsion or suspension of said composition on said substrate.

107. The method of Claim 92, wherein said curing step further comprises placing said substrate into a chamber, and evacuating said chamber.

108. The method of Claim 107, wherein said curing step further comprises passing an inert and/or reducing gas into said chamber.

109. The method of Claim 93, wherein said patterned thin film comprises a two-dimensional array of lines having a width of from 100 nm to 100 μm.

110. The method of Claim 109, wherein said lines have an inter-line spacing of from 100 nm to 100 μm.

111. The method of Claim 110, wherein said lines have a length of from 1 μm to 5000 μm.

112. The method of Claim 109, wherein said lines have a thickness of from 0.01 μm to 100 μm.

113. A thin film structure comprising a pattern of an electronically functional material on a substrate, said electronically functional material comprising sintered, photodefined nanoparticles of an electronically functional substance and having, prior to photodefinition and sintering, a ligand containing a group that is reactive with a photochemically generated species and which, after reacting with said photochemically generated species, materially changes the solubility characteristics of said nanoparticles in a developer.

114. The thin film structure of Claim 113, wherein said nanoparticles comprise semiconductor nanoparticles or metal nanoparticles.

115. The thin film structure of Claim 114, wherein said nanoparticles have a conductivity or resistivity no more than ten times that of the corresponding bulk semiconductor or metal.

116. The thin film structure of Claim 115, wherein said nanoparticles have a conductivity or resistivity no more than about five times that of the corresponding bulk semiconductor or metal.

117. The thin film structure of Claim 113, wherein said pattern comprises a two-dimensional array of lines having a width of from 100 nm to 100 μm.

118. The thin film structure of Claim 117, wherein said lines have an inter-line spacing of from 100 nm to 100 μm.

119. The thin film structure of Claim 117, wherein said lines have a length of from 1 μm to 5000 μm.

120. The thin film structure of Claim 117, wherein at least a subset of said lines have a length of from 2 μm to 1000 μm.

121. The thin film structure of Claim 117, wherein said lines have a thickness of from 0.01 μm to 100 μm.

122. The thin film structure of Claim 113, wherein said pattern has improved resolution relative to an otherwise identical electronically functional material sintered identically, but patterned by a graphics art-based process.

123. The thin film structure of Claim 122, wherein said otherwise identical electronically functional material does not have said group on said ligand.